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broad and hazy. The preceding classification is in good agreement with that (AO) derived by Dr. Adams[3], and that (A) listed in *The Henry Draper Catalogue*[4].

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1921 November 15.

THE SPIRAL NEBULA MESSIER 33

The two largest spirals recorded in the sky, the great nebula in *Andromeda* and the spiral in *Triangulum* present beautiful examples of the two great subdivisions of the spirals necessary in every attempt to classify these bodies, which show a greater variety among themselves than any other class of celestial objects. Photographs of Messier 33 (*Triangulum*) show some phenomena typical for many spirals of the same subdivision, which perhaps have been noted by observers, but still deserve to be pointed out. On small scale photographs the spiral appears as a bona fide nebulous object but photographed with large instruments especially the outer parts of the spiral arms seem to be resolved into numerous star-like objects. Many of these secondary nuclei look exactly like stars but a number of them have a soft appearance which has led Ritchey to call them nebulous stars. Now suppose the spiral consists of a great number of very distant stars; even on the largest scale photographs most of the stars will then be crowded together and give the impression of nebulous objects. Besides, the resolved stars are involved in what appears as a background of nebulosity that may be the vast number of unresolved bunches of faint stars; and thus the nebulous appearance of many of the secondary nuclei will be the more emphasized.

There is in the spiral structure a great number of dark lanes and it is to be noted that these do not always define the space between the spiral arms but many times go across them. Dr. Curtis raised the question whether there are whorls of dark matter between whorls of nebular matter and much pictorial evidence is in favor of this idea. Another question is: As the only difference between the rifts in Messier 33 and those in the Milky Way seems to be that the former have dimensions about 1/100 of the latter's, will that mean that the objects in the spiral are 100 times as far away as the corresponding objects in the Milky Way?

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[3] *Publ. A. S. P.*, **26**, 198, 1914.

[4] See *H. D.* No. 26976, *Harvard Annals*, **92**, 28.

A third phenomena of great interest is that, according to Max Wolf, more than 500 nebulous objects are recorded from the area surrounding Messier 33. Wolf found that these small nebulae are arranged in the extensions of the spiral arms. A graph in the writer's paper, "The Relations of the Globular Clusters and Spiral Nebulae to the Stellar System," Upsala 1920, illustrates the very peculiar distribution of Wolf's objects. There seems undoubtedly to be some relation between the small nebulae extending over an area of about 8°x8° and the spiral in the center. A long exposure Crossley photograph by Sanford shows that some of the nebulae apparently belonging to Messier 33 must have spiral structure. It is too early to speculate about spirals of different order, primary and secondary systems. The most natural explanation is perhaps that in this region we must expect to see several far away small spirals mixed up with nebular objects belonging to the great spiral. If the spaces between the spiral arms are filled with absorbing dark matter we get the impression of an arrangement in the extension of the spiral arms also of these background objects.

Photographs on Cramer Iso plates obtained this autumn with the Crossley reflector by using color screens confirm Seares's discovery that in spirals the outer parts of the object are richer in bluer light than the nucleus. To get information about the spectra of the spiral arms and the secondary nuclei spectrograms over regions in the spiral were obtained with Crossley reflecto as follows:

DATE	INSTRUMENT	EXPOSURE TIME
1921		
Oct. 28	Small (Keeler) quartz spectrograph	$5^h\ 0^m$
Oct. 29	" " " "	8 0
Sept. 29-Oct. 4	Large (Wright) " "	14 10
Nov. 2-5	" " " "	30 0
Nov. 6	" " " "	1 0

On the plate of October 29th a comparatively strong *continuous* spectrum of the spiral arms is seen on both sides of the nucleus to a distance of about 5′. No traces of bright lines are found in the general spectrum of the arms. The spectrogram with the larger dispersion shows the general continuous spectrum of the arms still farther out and a number of spectra of secondary nuclei and resolved stars. Some objects have a nebular spectrum but most of the objects belonging to the spiral show a strong continuous spectrum without bright lines. It is of course hard to give the accurate spectral type but the solar or a somewhat earlier type seems to be predominant. · From the spectral evidence it seems probable that the spiral nebula consists of ordinary stars, clusters of stars and some nebular matter.

The strongest of the nebulous objects is N.G.C. 604 earlier noted as a planetary or bright line nebula and found by Pease to have a radial velocity of −270 km./sec. The nebula is not a planetary but seems rather to be somewhat like the *Orion* nebula on a small scale, as 3 or 4 stellar nuclei are involved in irregular nebulosity. The nuclei give a continuous spectrum, apparently of early type stars, and the nebula gives a spectrum with bright images corresponding to the nebular lines N_1, N_2, $H\beta$, $H\gamma$, $H\delta$, 3869 and 3727, the last having the strongest intensity and most detailed structure of all the images. $H\gamma$ is probably blended with 4363.

From an unpublished investigation of the proper motion of 100 spiral nebulae, derived from micrometric and photographic measures, we give the following results for N.G.C. 604 measured as one mass to illustrate the accuracy of the measures.

Observer	EPOCH	$\alpha(1900)$ 1^h28^m	WEIGHT	RESIDUALS	$\delta(1900)$ $30°16'$	WEIGHT	RESIDUALS
d'Arrest	1863.9	$54^s.36$	0.2	$+0^s.32$	$6''.0$	0	......
Schönfeld	63.5	54 .90	1	−0 .22	18 .0	2	$-0''.5$
Schultz	71.4	54 .81	4	−0 .13	17 .0	4	+0 .4
Dreyer	90.3	54 .70	2	−0 .02	17 .0	3	+0 .1
Bigourdan	1889.8	54 .63	5	+0 .05	17. 2	5	−0 .1
Roberts	1900.0	54 .61	6	+0 .07	18 .1	6	−1 .1
Rheinmuth	02.7	54 .71	6	−0 .03	15 .8	6	+1 .1
Wirtz	1902.7	54 .63	4	+0 .05	17 .2	4	−0 .3

$$\mu\alpha = -0''.004 \pm 0''.002$$
$$\mu\delta = -0\ .015 \pm 0\ .021$$

van Maanen gives as the proper motion for the nucleus:

$$\mu\alpha = -0''.007$$
$$\mu\delta = -0\ .002$$

It is evident that the motion of both objects is very small. If we attribute to the brightest resolved stars in the spiral arms an absolute magnitude of -6^m (see the paper cited on p. 325) we get a parallax for the nebula of: $\pi = 0''.000003$.

Many other results from this and the paper quoted speak for a large distance. Comparison of the coarse clusters of resolved stars with the clusters in the Milky Way also indicate a large distance. From a photograph with the twin 6-inch telescope in Upsala it was found that the spiral appeared as a real nebulous object. As the stars then on the plate could be distinguished easily from the stars belonging to the nebula, star counts on this and other plates were made. It was found that the stars down to $15^m.7$ did not show any dependence upon the spiral nebula. It was then concluded that the spiral is more distant than stars of this magnitude, which means that the distance will be of the order of 10,000 light years or larger.

A more detailed account of the spectrographic and photographic results will be given later in connection with further observational work on this object.

KNUT LUNDMARK.

Mt. Hamilton, November 20, 1921.

GENERAL NOTES

The Drake University Municipal Observatory.—The formal dedication of the Drake University Municipal Observatory, at Des Moines, Iowa, on Saturday, November 5, 1921, was an event of more than local importance. In the first place it marks the realization of a dream. Twenty years ago, Professor D. W. Morehouse, of Drake University, "walked over the Waveland park grounds and said to himself that the sightly knoll in the middle of that beautiful public park was the place for an astronomical observatory. . . . But between noting the availability of the site and actually getting a building of stone and concrete with all the modern equipment there was a lapse of twenty years, of more or less continuous effort, most of them years of no hope and great discouragement[1]."

In the second place, the observatory, representing an investment of $53,000, was built thru the combined efforts of Drake University and the city of Des Moines. This spirit of cooperation is worthy of all honor, and particularly the honor of imitation by other cities and colleges. So far, we believe, the institution is unique. The school department of the city of Oakland, California, owns the fine Chabot Observatory, and uses it, under the directorship of Mr. Charles Burckhalter, in the education of grammar and high school

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[1] *Des Moines Evening Tribune.*